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Abstract

This paper examines student perceptions of micro-quadcopter flights in a higher education setting through a case study format. The purpose of the flight activity discussed is to allow students to familiarize themselves with quadcopter flight characteristics, as early as possible, at their own pace in a low stress environment. Through a series of interviews with students who had taken a course where this activity was performed it was found that students enjoyed the activity and found it engaging. Some students felt that the activity provided them confidence for later courses, and many felt that it helped teach basic quadcopter control. It was also found that if the activity is repeated in later courses it should include some form of directed activity, instead of focusing on "free flight". Several students brought up another activity in the course, simulator flights, and these are briefly discussed. Future work should look to find if these activities have a positive effect on student flight performance.

Background

Unmanned Aerial Systems UAS programs offering Associate's or Bachelor's degrees are present at many universities and colleges across the United States. These programs vary in their requirements, and many mirror traditional professional pilot programs while others require manned flight certificates (Wentworth, 2017). The UAS program being discussed in this paper requires 120 credit hours, 24 of which are UAS specific, and 22 aviation courses related to UAS. The UAS program is the newest major at the school that includes professional pilot, aviation maintenance, and aviation management degree programs. There is a heavy lab focus in the UAS major with 16 of the 24 UAS specific credit hours are spent in various UAS labs. These labs teach UAS construction, manual flight, autonomous flight, data collection, data analysis, and problem solving with UAS. The learning activity investigated in this paper took place from the Fall 2017 to Fall 2018 semesters across two courses. For this paper these courses will be called UAS1 and UAS2. The course objectives for UAS1 is to introduce new major students to the UAS field and how UAS operate. This objective is met through construction of a Sig Kadet Mk II in small groups, individual micro quadcopter flights, and UAS flight simulators. The last two activities were added in the Fall 2017 semester because of the instructor's belief they would add learning value to the class, and as a way to mirror the professional pilot program present at the university.

The Blade Nano QX, will also be referred to as "Nano", was chosen for the micro-quadcopter flights due to their size, stability, and cost. These vehicles are 16.5grams in flight with a length and width of under 3 inches. The Blade Nano QX has an auto-stabilize feature, called "safe technology", that limits the vehicle pitch and bank angle and will auto level when pitch or bank control is neutralized (Flysaferc, 2013). This system is not the same type of auto-stabilize system that is present larger commercial vehicles, which will keep the current position of the vehicle without user input. The size of these vehicles makes them easy to fly indoors, and the auto-stabilization feature is intended to make the vehicles easy for new pilots to fly. A ready to fly package for the Nano can be found on Amazon which allowed a small fleet of 10. The vehicles and additional batteries are also able to be easily purchased.

UAS1 introduced the Nano flight activity, which required students to accumulate 4 hours of flight time with the vehicles throughout the semester. These flights could be accomplished during lab time or the instructor's office hours. The flights were performed without activity direction, i.e. the students were not told where to fly or what do while flying. For the flight area students determined the flight activities they would perform in a large open room. This activity was repeated in UAS1 Spring 2018 and UAS2. The same fleet of Nanos was used for all the classes mentioned in this paper with each vehicle receiving an average of 8.8 hours of flight time at the end of UAS1. Assuming all students correctly reported the hours they flew each vehicle would have begun UAS2 with 17.6 flight hours and ended with 26.4 flight hours. In addition to the flight hours each vehicle received they were also subjected to a variety of crashes as the students learned how to operate them effectively.

UAS2 added to the Nano flights with tasks such as; precision landing, orientation control, and precision flight. Precision landing involved landing pads that were slightly larger than the vehicle placed around the large lab table approximately 4 feet by 10 feet. The students would take-off from one landing pad and navigate to another approximately 4-5 feet away and land. Orientation control involved taking-off from a pad circling a pole and landing on the pad the flight started from. There were two tasks involved with flying around the pole; 1. Fly around the pole in any orientation without hitting the pole, 2. Fly around the pole keeping the nose of the vehicle facing towards the pole for the entire flight. Precision flight involved replicating a drone racing league (DRL) course. Students would fly around a predetermined course while being timed with the fastest time being considered the "winner". For all of these tasks students had as many tries as they wanted.

Analysis of Interview Transcripts

To evaluate student perceptions of micro UAS flights seven former students participated in 5-12 minute interviews focusing on their perceptions of the Blade Nano flights and the class. The participants had all taken UAS1 with four students having taken other courses in the program, in addition to the following course UAS2. The number of other UAS courses taken by each participant varies due to the freedom of course selection in the major, and class standing when UAS1 and UAS2 were taken. The first experience from the participants that became apparent is that the wide range of flight time concentrated at the extremes. The extremes varied from no prior flight experience to over 2,000 hours of flight time. These hours were self-reported and not logged, but the students who had a high amount of flight hours also said they had been flying for years. Due to the lack of flight logs it is impossible to know exactly how many hours they have, participants with a high hour time were assumed to be very experienced with UAS flight. One commonality between the inexperienced and experienced participants was DJI products. Participants who mentioned gaining flight experience outside of class, either before or after taking the course, stated that they gained their multirotor time from primarily DJI products. All participants mentioned the lack of fixed wing flight time in the class as a negative when asked about feedback regarding the Nano flights. This is mentioned as a drawback of the class with the classroom being too small for fixed wing flight to be performed adequately. Small fixed wings were attempted to be flown but lacked enough space to be operated.

When discussing the Blade Nano flights all participants stated that they had a positive view of the activity, but some negatives were also mentioned. The biggest negative mentioned was the flight characteristics of the vehicles. Flight conditions were broken down into three complaints; no auto-stabilize, worn condition, and battery life. The participants mentioned that the Nano's lack of auto-stabilize feature made the flights daunting to those who had no experience with quadcopter flight. As mentioned in the description of the Nanos, they do contain an auto-stabilize feature, but it is not as robust as what can be found on larger commercial platforms such as DJI. This is likely why the participants mentioned the lack of this feature. The lack of auto-stabilize was also stated as a positive by a participant stating that they felt it "reinforced manual flight control techniques" and another participant stated that the Nano performance gave confidence for later courses. The worn condition of the Nanos is brought up by participants who took UAS1. This used condition negatively affected vehicle performance and each vehicle performed differently due to the varying degrees of damages on the vehicles. One participant did mention that the vehicle discrepancies helped them to internalize problem diagnosis and solving. An example of this is on many occasions a propeller would not rotate on one of the vehicles. This could be due to a foreign object wrapped around a motor shaft or a dead motor. The corrective action for this problem can be removal of the propeller and removing the foreign object or completely exchange the motor. Multiple participants brought up the short battery life of the vehicles, while this is a limitation of the technology steps were taken in the course to address the issue. During the first few weeks of the initial offering of the course it became obvious that battery size would be a limitation of the vehicles and thirteen additional batteries were purchased doubling the amount of batteries available and leaving each quad with 3 batteries. While the short flight times were described as a negative of the vehicles, the short charge time of the batteries was noted as a positive. This short charge time and number of batteries available did not eliminate down time while all batteries were dead or charging but did reduce the frequency.

The Nano flights were repeated in UAS2 due to the assumed helpful nature and the fact that students enjoyed the activity. The feedback from the students that participated in UAS1 and

UAS2 provides interesting insight into developing Nano flights for multiple courses. The original idea was to repeat the activity in UAS2 so students could continue to familiarize themselves with multirotor flight characteristics at their own pace. The three participants who had taken both courses did not like this approach as the activity felt repetitive leading them to dislike it. This became apparent in the course quickly as the instructor began providing obstacle race courses for students to participate in. Three of the participants mention being engaged in these activities, and one mentions regretting not taking advantage of them in the class. Both courses were mentioned as being fun and engaging as well as helping to develop the students advance flying techniques.

One participant felt that the Nano flight activity provided a challenge as an experienced pilots however the experienced pilots were much "quicker to get the hang of it". This could suggest that even experienced pilots have an experience gap, possibly due to most of their flight experience being with a vehicle that has many pilot assist features. A participant also noted an increase in situational awareness while flying due to the number of vehicles that would be flying in the room simultaneously. This forced students who were flying to keep an eye out for other student vehicles and anticipate their movements in addition to controlling their vehicle. This was accomplished very well as the instructor only remembers a handful of mid-air collisions during the three times this activity was performed.

Discussion

This difference in experience makes engaging curriculum design for introductory courses difficult as some students are complete beginners and others are more experienced than the instructors. Even though the more advanced pilots initially struggled when they first flew the Nanos they gained control of the vehicle much more quickly than beginner pilots. One way to counter this would be to immediately introduce the more advanced techniques such as the landing pads or flying through and obstacle course, however if it is dominated by the advanced pilot or appeared to be made easy it can be very discouraging to beginner pilots. Through having multiple courses that focus on the various aspect of flying could be a way to encourage students to practice flying, such as having all three courses mentioned active at the same time and as students feel more confident allow them to attempt each course as they wish. By having no point values assigned to flying the courses allowing the students to not have to deal with the additional stresses of flying for a score.

One of the common complaints throughout the interviews were the lack of fixed wing experience. This was attempted to be mitigated through the fixed wing simulator flights, however this was mentioned, and the participants would have preferred actual flight experience in addition to the sims. This presents a challenge for the class as there are no classrooms that contain a large outdoor air field to fly on. This was attempted to be mitigated through having small indoor aircraft to fly, but it was soon found that the largest room available was still too small to provide adequate room for flying.

One item that was brought up during the interviews was the simulator flights that the students were required to do in addition to the Blade Nano flights. There were two set of challenges required for students to complete the fixed wing and the multirotor. These simulator flights were found to be beneficial to the participants although they were considered challenging. One of the positives that was mentioned about the simulator flights was that it provided the students with fixed wing experience, even if the only experience with fixed wing was on the simulator. Some of the drawbacks of the simulators involved lack of stations and difficulty of some of the challenges**.** In the down time of the Nanos charging students were able to attempt the simulator flights, however they felt that while the batteries were charging most would end up gathering around the computer and watching one person complete them due to their only being one seat available for the sims. With the challenges themselves students found that the fixed wing represented the most realistic course as it was replicated similar to the red bull air race. Students were required to fly through a set of pylons as quickly as possible for a score out of 100 points. For the quadcopter trials there were gates and landing pads that students needed to fly through or land on, this is where the dislike for the challenges came since to complete the challenges students had to fly their vehicles full speed into the ground or wall. This allowed completion of the challenge but enforced poor flying habits.

Conclusion

In conclusion this case study has found that the students who participated thought the micro-quadcopter flight activity to be useful and engaging. One student mentions that it helped build confidence for later courses, and multiple students stated that it helped teach basic control. It was also found that if this activity is to be integrated into multiple courses then it must be modified for each course. The students who had taken UAS2 mentioned that repeating the “free flight” activity was not engaging when done a second time, but the modifications made to the activity made it engaging. The interviews also suggest that the Nanos may not stand up to multiple semesters of novice UAS pilots, and may need to be replaced regularly due to about a third of the vehicles being used for spare parts. While not the focus of the study it would seem that the simulator activities had a large effect on student perceptions of the class. One participant was a very adamant supporter of the simulator activities, and after this interview questions about the simulators were asked in subsequent interviews.

Future Work

Future research should be done to determine the effect of these type of activities on student flight performance. This study suggests that students view the activity positively but it cannot determine the actual effect of the activity on their performance. The effect of the simulator activities should also be investigated. As UAS education becomes a regular part of higher education activities like this could provide a low cost introduction to flight, and help teach advanced flight skills. It should be determined early on how useful these methods are to that goal, and how they may be improved or if other methods should be used.

References

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